

**Claims**

We claim:

1. A light-emitting device, comprising:
  - a light source; and
  - a gradient index (GRIN) element having a cylindrical refractive index profile in which the refractive index varies radially and is substantially constant axially, the GRIN element comprising a first end surface opposite a second end surface and characterized by a length-to-pitch ratio, the GRIN element arranged with the first end surface adjacent the light source to receive light therefrom and emitting the light from the second end surface in a radiation pattern dependent on the length-to-pitch ratio.
2. The light-emitting device of claim 1, in which:
  - the length-to-pitch ratio is equal to one fourth; and
  - the GRIN element emits the light in a collimated beam.
3. The light-emitting device of claim 1, in which:
  - the length-to-pitch ratio is less than one fourth; and
  - the GRIN element emits the light in a diverging beam.
4. The light-emitting device of claim 1, in which:
  - the length-to-pitch ratio is between than one fourth and one half; and
  - the GRIN element emits the light in a converging beam.
5. The light-emitting device of claim 1, in which:
  - the length-to-pitch ratio is equal to one half; and
  - the GRIN element emits the light from a point source.

6. The light-emitting device of claim 1, in which:  
the light-emitting device additionally comprises a header comprising a threaded portion;  
the light source is mounted on the header;  
5 the GRIN element comprises a threaded portion; and  
the threaded portion of the header is engaged with the threaded portion of the GRIN element.

7. The light-emitting device of claim 6, additionally comprising index matching material located in the cavity.

8. The light-emitting device of claim 6, in which:  
the GRIN element defines a cavity comprising a side wall in which the threaded portion of the GRIN element is defined; and  
the header comprises an external curved surface in which the threaded portion of  
5 the header is defined.

9. The light-emitting device of claim 6, in which:  
the header defines a cavity comprising a side wall in which the threaded portion of the header is defined; and  
the GRIN element comprises an external curved surface in which the threaded portion of the GRIN element is defined.  
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10. The light-emitting device of claim 1, in which:  
the light-emitting device additionally comprises a header;  
the header comprises a cavity extending thereinto;  
the light source is mounted in the cavity defined in the header; and  
5 the GRIN element is engaged with the cavity by a push fit.

11. The light-emitting device of claim 10, additionally comprising index matching material located in the cavity.

12. The light source of claim 1, in which the light source comprises a semiconductor die.

13. A method of making a light emitting device, the method comprising:
- providing a light source;
- providing a GRIN element having a cylindrical refractive index profile in which the refractive index varies radially and is substantially constant axially, the GRIN
- 5 element comprising a first end surface opposite a second end surface and characterized by a length-to-pitch ratio; and
- arranging the GRIN element with the first end surface thereof adjacent the light source to receive light therefrom, the GRIN element emitting the light from the second end surface in a radiation pattern that depends on the length-to-pitch ratio.
14. The method of claim 13, in which:
- providing a GRIN element comprises:
- providing GRIN elements each having a cylindrical refractive index profile, comprising a first end surface opposite a second end surface, and
- 5 characterized by respective length-to-pitch ratio, the length-to-pitch ratios differing among the GRIN elements, and
- selecting one of the GRIN elements as a selected GRIN element, the selected GRIN element having a length-to-pitch ratio corresponding to a desired radiation pattern; and
- 10 in the arranging, the selected GRIN element is arranged with the first end surface thereof adjacent the light source.

15. The method of claim 13, in which providing a GRIN element comprises:

providing an elongate rod having a cylindrical refractive index profile

characterized by a pitch; and

dividing off from the rod a lengthwise portion to provide the GRIN element.

16. The method of claim 15, additionally comprising dividing the rod lengthwise into portions, ones of the portions having different lengths to provide the GRIN elements of light-emitting devices having different radiation patterns.

17. The method of claim 12, additionally comprising:  
providing an additional GRIN element having a cylindrical refractive index profile, comprising a first end surface opposite a second end surface and characterized by a length-to-pitch ratio different from the length-to-pitch ratio of the GRIN element; and  
5 substituting the additional GRIN element for the GRIN element to change the radiation pattern of the light-emitting device.

18. The method of claim 13, in which:  
providing a light source comprises:  
providing a header comprising a threaded portion, and  
mounting the light source on the header;  
5 the GRIN element comprises a threaded portion; and  
the arranging comprises engaging the threaded portion of the header with the threaded portion of the GRIN element.

19. The method of claim 18, additionally comprising partially suggestion : Take out this word. filling the cavity with index-matching material.

20. The method of claim 18, in which:  
the GRIN element defines a cavity comprising a side wall in which the threaded portion of the GRIN element is defined; and  
the header comprises an external curved surface in which the threaded portion of  
5 the header is defined.

21. The method of claim 18, in which:

the header defines a cavity comprising a side wall in which the threaded portion of the header is defined; and

5       the GRIN element comprises an external curved surface in which the threaded portion of the GRIN element is defined.

22. The method of claim 13, in which:

providing a light source comprises:

      providing a header, the header defining a cavity, and  
      mounting the light source in the cavity; and

5       the arranging comprises inserting a portion of the GRIN element into the cavity.